C/2024/5880

27.9.2024

Compilation of national control lists under Article 9(4) of Regulation (EU) 2021/821 of the European Parliament and of the Council of 20 May 2021 setting up a Union regime for the control of exports, brokering, technical assistance, transit and transfer of dual-use items [1]

(C/2024/5880)

Article 9(4) of Regulation (EU) 2021/821 (hereunder 'the Regulation') requires the publication in the *Official Journal of the European Union* of a compilation of national control lists in force in the Member States and notified to the Commission and the other Member States pursuant to Article 9 of the Regulation.

Article 10(1) of the Regulation enables other Member States to impose an authorisation requirement for the export of items on the basis of a national control list adopted by a Member State and published by the Commission pursuant to Article 9(4) of the Regulation.

This information note compiles the national control lists adopted by Spain on 31 May 2023, The Netherlands on 23 June 2023 and France on 2 February 2024; and notified pursuant to said Article 9(2) of the Regulation.

Unless otherwise specified in the entries below, the national control lists are applicable for exports to all destinations outside the customs territory of the Union.

Unless otherwise specified in the entries below, the definitions in Annex I of the Regulation apply *mutatis mutandis*.

CATEGORY 1 – SPECIAL MATERIALS AND RELATED EQUIPMENT

1B Test, Inspection and Production Equipment

1B1901 [2]

Issued by Spain [3]

Additional information:

Description of the controlled items:

Additive manufacturing equipment designed or modified to produce, from energetic materials, explosive, pyrotechnic or propellant devices or shapes, and having any of the following characteristics:

a. Designed or modified to comply with the national safety standards applicable to environments containing potentially explosive ammunition; or

b. One or more ultrasonic extruders.

CATEGORY 3 - ELECTRONICS

3A Systems, Equipment and Components

3A1901.a.15 [4]

Issued by France [5]

[1] OJ L 206, 11.6.2021, p. 1.
[2] Equivalent national code: 1.B.901.
[3] Annex III.5 of the Royal Decree 679/2014 of 1 August 2014, with entry into force on 7 June 2023.
[4] Equivalent national code: 3A901.a.15.
[5] Order of 2 February 2024 on exports to third countries of goods and technologies associated with quantum computers and their enabling technologies, and of equipment to design, develop, produce, test and inspect advanced electronic components.

Additional information:

Description of the controlled items:

Complementary Metal Oxide Semiconductor (CMOS) integrated circuits, not specified in 3A001.a.2. of the Regulation, designed to operate at an ambient temperature equal to or less (better) than 4.5 K (-268.65°C).

Technical Note

For the purposes of 3A1901.a.15, CMOS integrated circuits are also referred to as cryogenic CMOS or cryo-CMOS.

3B Test, Inspection and Production Equipment

3B1001.a.4 ([6])

Issued by The Netherlands ([7])

Additional information:

Description of the controlled items:

Equipment designed for silicon (Si), carbon doped silicon, silicon germanium (SiGe), or carbon doped SiGe epitaxial growth, with all of the following characteristics:

1. Multiple chambers and maintaining high vacuum (equal to or less than 0.01 Pa) or an inert environment (water and oxygen partial pressure less than 0.01 Pa) between process steps;
2. At least one pre-treatment chamber designed for a surface preparation to clean the surface of wafers; and
3. An epitaxial deposition operating temperature of 685°C or less.

3B1001.d.12 ([8])

Issued by The Netherlands ([9])

Additional information:

Description of the controlled items:

Equipment for Atomic Layer Deposition (ALD) of 'work function' metals

a. with all of the following characteristics:
    1. More than one metal source, one of which has been developed for an aluminium (Al) starting material ('precursor'); and
    2. Precursor vessel designed for temperatures exceeding 45°C; and
b. Designed for depositing a 'work function' metal with all of the following characteristics:
    1. Titanium aluminium carbide (TiAlC) deposition; and
    2. Enabling a 'work function' greater than 4.0 eV.

([6]) Equivalent national code: 3B001.a.4.
([7]) Regulation of the Minister for Foreign Trade and Development Cooperation of 23 June 2023, no. MinBuza.2023.15246-27 introducing a license obligation for the export of advanced production equipment for semiconductors that are not mentioned in Annex I of Regulation 2021/821 (Regulation on advanced production equipment for semiconductors), with entry into force on 1 September 2023.
([8]) Equivalent national code: 3B001.d.12.
([9]) Regulation of the Minister for Foreign Trade and Development Cooperation of 23 June 2023, no. MinBuza.2023.15246-27 introducing a license obligation for the export of advanced production equipment for semiconductors that are not mentioned in Annex I of Regulation 2021/821 (Regulation on advanced production equipment for semiconductors), with entry into force on 1 September 2023.

Technical Note

1. *'Work function metal' is a material that regulates the threshold voltage of a transistor.*

3B1001.d.19 ([10])

Issued by The Netherlands ([11])

Additional information:

Description of the controlled items:

Equipment designed for enhanced void-free plasma deposition of a low-k dielectric layer in gaps between metal lines less than 25 nm wide and having an aspect ratio greater than or equal to 1:1, with a less than 3.3 dielectric constant.

3B1001.f.4 ([12])

Issued by The Netherlands ([13])

Additional information:

Description of the controlled items:

Lithographic equipment as follows:

a. Align and expose step and repeat (direct step on wafer) or step and scan (scanner) equipment for wafer processing using photo-optical or X-ray methods and having any of the following:
   1. a light source wavelength shorter than 193 nm; or
   2. a light source wavelength equal to or longer than 193 nm:
      a. capable of producing a pattern with a 'Minimum Resolvable Feature size' (MRF) of 45 nm or less; and
      b. a maximum 'dedicated chuck overlay' (DCO) value less than or equal to 1.50 nm.

Technical note:

1. *The 'Minimum Resolvable Feature size' (MRF) is calculated using the following formula:*

$$\text{'MRF'} = \frac{\text{(an exposure light source wavelength in nm) x (K factor)}}{\text{Maximum numerical aperture}}$$

where the K factor = 0.25.

'MRF' is also known as resolution.

2. *'Dedicated chuck overlay' is the alignment accuracy of a new pattern to an existing pattern printed on a wafer by the same lithographic system.*

([10]) Equivalent national code: 3B001.d.19.

([11]) Regulation of the Minister for Foreign Trade and Development Cooperation of 23 June 2023, no. MinBuza.2023.15246-27 introducing a license obligation for the export of advanced production equipment for semiconductors that are not mentioned in Annex I of Regulation 2021/821 (Regulation on advanced production equipment for semiconductors), with entry into force on 1 September 2023.

([12]) Equivalent national code: 3B001.f.4.

([13]) Regulation of the Minister for Foreign Trade and Development Cooperation of 23 June 2023, no. MinBuza.2023.15246-27 introducing a license obligation for the export of advanced production equipment for semiconductors that are not mentioned in Annex I of Regulation 2021/821 (Regulation on advanced production equipment for semiconductors), with entry into force on 1 September 2023.

3B1001.l ([14])

Issued by The Netherlands ([15])

Additional information:

Description of the controlled items:

EUV pellicles

3B1001.m ([16])

Issued by The Netherlands ([17])

Additional information:

Description of the controlled items:

Production equipment for EUV pellicles

3B1901 ([18])

Issued by Spain ([19])

Additional information:

Description of the controlled items:

Scanning electron microscope equipment designed for imaging semiconductor devices or integrated circuits, having all of the following characteristics:

a. Stage positioning accuracy equal to or less than 30 nm;

b. Stage positioning accuracy performed laser interferometry;

c. Position calibration within a field-of-view based on laser interferometer length-scale measurement;

d. Ability to collect and store images having more than $2x10^8$ pixels;

e. Field-of-view overlap of less than 5 % in vertical and horizontal directions;

f. Stitching overlap of field of view of less than 50 nm; and

g. Accelerating voltage more than 21 kV;

Note:

3B1901 includes scanning electron microscope equipment designed for the repair of chips.

3B1902 ([20])

Issued by Spain ([21])

([14]) Equivalent national code: 3B001.l.

([15]) Regulation of the Minister for Foreign Trade and Development Cooperation of 23 June 2023, no. MinBuza.2023.15246-27 introducing a license obligation for the export of advanced production equipment for semiconductors that are not mentioned in Annex I of Regulation 2021/821 (Regulation on advanced production equipment for semiconductors), with entry into force on 1 September 2023.

([16]) Equivalent national code: 3B001.m.

([17]) Regulation of the Minister for Foreign Trade and Development Cooperation of 23 June 2023, no. MinBuza.2023.15246-27 introducing a license obligation for the export of advanced production equipment for semiconductors that are not mentioned in Annex I of Regulation 2021/821 (Regulation on advanced production equipment for semiconductors), with entry into force on 1 September 2023.

([18]) Equivalent national code: 3.B.901.

([19]) Annex III.5 of the Royal Decree 679/2014 of 1 August 2014, with entry into force on 7 June 2023.

([20]) Equivalent national code: 3.B.902.

([21]) Annex III.5 of the Royal Decree 679/2014 of 1 August 2014, with entry into force on 7 June 2023.

Additional information:

Description of the controlled items:

Equipment designed for dry etching having any of the following characteristics:

1. Equipment designed or modified for isotropic dry etching, having a silicon germanium-to-silicon (SiGe:Si) etch selectivity greater than or equal to 100:1; or
2. Equipment designed or modified for anisotropic dry etching, having all of the following characteristics;
   a. Radio frequency power sources with at least one pulsed radio frequency output;
   b. Fast gas-switching valves with switching time of less than 300 milliseconds; and
   c. Electrostatic chuck with twenty or more controllable variable temperature elements.

Note 1:

3B1902 includes etching by radicals, ions, sequential reactions or non-sequential reactions.

Note 2:

3B1902 includes etching using RF pulse-excited plasma, pulsed duty-cycle excited plasma, plasma modified with pulsed voltage on electrodes, cyclic injection and purging of gases combined with a plasma, plasma atomic layer etching or plasma quasi-atomic layer etching.

Technical Note 1:

For the purpose of 3B1902, silicon germanium-to-silicon (SiGe:Si) etch selectivity is measured for a Ge concentration of greater than or equal to 30 % ($Si_{0,70}Ge_{0,30}$).

Technical Note 2:

For the purpose of 3B1902, a radical is defined as an atom, molecule, or ion that has an unpaired electron in an open electron shell configuration.

3B1903 ([22])

Issued by France ([23])

Additional information:

Description of the controlled items:

Scanning Electron Microscope (SEM) designed for imaging semiconductor devices or integrated circuits, having all of the following:

a. Stage positioning accuracy less (better) than 30 nm;
b. Stage positioning measurement performed using laser interferometry;
c. Position calibration within a field-of-view (FOV) based on laser interferometer length-scale measurement;
d. Collection and storage of images having more than 2 x 10^8 pixels;
e. FOV overlap of less than 5 % in vertical and horizontal directions;
f. FOV overlap of less than 50 nm; and
g. Accelerating voltage greater than 21 kV.

([22]) Equivalent national code: 3B903.
([23]) Order of 2 February 2024 on exports to third countries of goods and technologies associated with quantum computers and their enabling technologies, and of equipment to design, develop, produce, test and inspect advanced electronic components.

Note 1:

3B1903 includes SEM equipment designed for chip design recovery.

Note 2:

3B1903 does not apply to SEM equipment designed to accept a SEMI standard wafer carrier, such as a 200 mm or larger Front Opening Unified Pod (FOUP).

3B1904 ([24])

Issued by France ([25])

Additional information:

Description of the controlled items:

Equipment designed for dry etching having all of the following:

1. Equipment designed or modified for isotropic dry etching, having a largest 'silicon germanium-to-silicon (SiGe:Si) etch selectivity' of greater than or equal to 100:1; or
2. Equipment designed or modified for anisotropic dry etching, having all of the following;
   a. Radio frequency (RF) power sources with at least one pulsed radio frequency output;
   b. One or more fast gas switching valves with switching time of less than 300 milliseconds; and
   c. Electrostatic chuck with twenty or more controllable variable temperature elements.

Note 1:

3B1904 includes etching by 'radicals', ions, sequential reactions, or non-sequential reactions.

Note 2:

3B1904 includes etching using RF pulse excited plasma, pulsed duty cycle excited plasma, pulsed voltage on electrodes modified plasma, cyclic injection and purging of gases combined with a plasma, plasma atomic layer etching, or plasma quasi-atomic layer etching.

Technical Note 1:

For the purposes of 3B1904, 'silicon germanium-to-silicon (SiGe:Si) etch selectivity' is measured for a Ge concentration of greater than or equal to 30 % (Si0.70Ge0.30).

Technical Note 2:

For the purposes of 3B1904, 'radical' is defined as an atom, molecule, or ion that has an unpaired electron in an open electron shell configuration.

3D Software

3D1007 ([26])

Issued by The Netherlands ([27])

([24]) Equivalent national code: 3B901.k.
([25]) Order of 2 February 2024 on exports to third countries of goods and technologies associated with quantum computers and their enabling technologies, and of equipment to design, develop, produce, test and inspect advanced electronic components.
([26]) Equivalent national code: 3D007.
([27]) Regulation of the Minister for Foreign Trade and Development Cooperation of 23 June 2023, no. MinBuza.2023.15246-27 introducing a license obligation for the export of advanced production equipment for semiconductors that are not mentioned in Annex I of Regulation 2021/821 (Regulation on advanced production equipment for semiconductors), with entry into force on 1 September 2023.

Additional information:

Description of the controlled items:

Software specially designed for the development, production or use of the goods specified in this scheme under headings 3B1001.l, 3B1001.m, 3B1001.f.4, 3B1001.d.12, 3B1001.a.4 or 3B1001.d.19.

3D1901 ([28])

Issued by Spain ([29])

Additional information:

Description of the controlled items:

Software designed to extract GDSII or equivalent standard layout data and perform layer-to-layer alignment from scanning electron microscope images, and generate a multi-layer GDSII data or a circuit netlist.

Technical note:

GDSII (Graphic Design System II) means a database file format for data exchange of integrated circuit artwork or integrated circuit layout artwork.

3D1902 ([30])

Issued by France ([31])

Additional information:

Description of the controlled items:

'Software' specially designed for the 'use' of equipment specified in 3B1904.

3D1907 ([32])

Issued by France ([33])

Additional information:

Description of the controlled items:

'Software' designed to extract GDSII or equivalent standard layout data and perform layer-to-layer alignment from scanning electron microscope images, and generate multi-layer GDSII data or the circuit netlist.

Note:

'GDSII' ('Geometrical Database Standard II') format is a database file format for data exchange of integrated circuit artwork or integrated circuit layout artwork.

([28]) Equivalent national code: 3.D.901.
([29]) Annex III.5 of the Royal Decree 679/2014 of 1 August 2014, with entry into force on 7 June 2023.
([30]) Equivalent national code: 3.D.902.
([31]) Order of 2 February 2024 on exports to third countries of goods and technologies associated with quantum computers and their enabling technologies, and of equipment to design, develop, produce, test and inspect advanced electronic components.
([32]) Equivalent national code: 3D907.
([33]) Order of 2 February 2024 on exports to third countries of goods and technologies associated with quantum computers and their enabling technologies, and of equipment to design, develop, produce, test and inspect advanced electronic components.

3E Technology

3E1005 ([34])

Issued by The Netherlands ([35])

Additional information:

Description of the controlled items:

Technology which is required for the development, production or use of goods specified in this scheme under headings 3B1001.l, 3B1001.m, 3B1001.f.4, 3B1001.d.12, 3B1001.a.4 or 3B1001.d.19.

3E1901 ([36])

Issued by Spain ([37])

Additional information:

Description of the controlled items:

Technology for the development or production of scanning electronic microscopes specified in 3B1901.

3E1902 ([38])

Issued by Spain ([39])

Additional information:

Description of the controlled items:

Technology for the development or production of software specified in 3D1901.

3E1903 ([40])

Issued by Spain ([41])

Additional information:

Description of the controlled items:

Technology for the development or production of equipment designed for dry etching specified by 3B1902.

3E1904 ([42])

Issued by Spain ([43])

Additional information:

Description of the controlled items:

([34]) Equivalent national code: 3E005.
([35]) Regulation of the Minister for Foreign Trade and Development Cooperation of 23 June 2023, no. MinBuza.2023.15246-27 introducing a license obligation for the export of advanced production equipment for semiconductors that are not mentioned in Annex I of Regulation 2021/821 (Regulation on advanced production equipment for semiconductors), with entry into force on 1 September 2023.
([36]) Equivalent national code: 3.E.901.
([37]) Annex III.5 of the Royal Decree 679/2014 of 1 August 2014, with entry into force on 7 June 2023.
([38]) Equivalent national code: 3.E.902.
([39]) Annex III.5 of the Royal Decree 679/2014 of 1 August 2014, with entry into force on 7 June 2023.
([40]) Equivalent national code: 3.E.903.
([41]) Annex III.5 of the Royal Decree 679/2014 of 1 August 2014, with entry into force on 7 June 2023.
([42]) Equivalent national code: 3.E.904.
([43]) Annex III.5 of the Royal Decree 679/2014 of 1 August 2014, with entry into force on 7 June 2023.

Technology for the development or production of integrated circuits or devices, using gate all-around field-effect transistor structures (GAAFET).

3E1905 ([44])

Issued by France ([45])

Additional information:

Description of the controlled items:

'Technology' within the meaning of the General Technology Note in Annex I to the Regulation for the 'development' or 'production' of integrated circuits and devices using 'gate-all-around field-effect transistor' ('GAAFET') structures.

Note 1:

3E1905 includes 'process recipes'.

Note 2:

3E1905 does not apply to tool qualification or maintenance.

Note 3:

3E1905 does not control 'Process Design Kits' ('PDK'), unless they include libraries implementing functions or technologies for items specified in 3A001 of Annex I to the Regulation or 3A1901.a.15.

Technical Notes:

For the purposes of 3E1905, a 'process recipe' is a set of conditions and parameters for a particular step of a process. A 'Process Design Kit' or 'PDK' is a software tool provided by a semiconductor manufacturer to ensure that the required design practices and rules are taken into account in order to produce a specific integrated circuit design in a specific semiconductor process, in accordance with technological and manufacturing constraints (each semiconductor manufacturing process has its particular 'PDK').

3E1906 ([46])

Issued by France ([47])

Additional information:

Description of the controlled items:

'Technology' within the meaning of the General Technology Note in Annex I to the Regulation for the 'development' or 'production' of equipment or materials specified in 3A1901.a.15, 3B1904, 3B1903.

Note:

3E1906 does not control 'Process Design Kits' ('PDK'), unless they include libraries implementing functions or technologies for items specified in 3A001 of Annex I to the Regulation or 3A1901.a.15.

([44]) Equivalent national code: 3E905.
([45]) Order of 2 February 2024 on exports to third countries of goods and technologies associated with quantum computers and their enabling technologies, and of equipment to design, develop, produce, test and inspect advanced electronic components.
([46]) Equivalent national code: 3E901.
([47]) Order of 2 February 2024 on exports to third countries of goods and technologies associated with quantum computers and their enabling technologies, and of equipment to design, develop, produce, test and inspect advanced electronic components.

Technical Note:

A 'Process Design Kit' or 'PDK' is a software tool provided by a semiconductor manufacturer to ensure that the required design practices and rules are taken into account in order to produce a specific integrated circuit design in a specific semiconductor process, in accordance with technological and manufacturing constraints (each semiconductor manufacturing process has its particular 'PDK').

CATEGORY 4 – COMPUTERS

4A Systems, Equipment and Components

4A1901 ([48])

Issued by Spain ([49])

Additional information:

Description of the controlled items:

Quantum computers and related electronic assemblies and components therefor, as follows:

a. Quantum computers, in accordance with the following requirements:

   1. Quantum computers supporting 34 or more, but fewer than 100, fully controlled, connected and working physical qubits, and having a C-NOT error of less than or equal to 10^{-4};

   2. Quantum computers supporting 100 or more, but fewer than 200, fully controlled, connected and working physical qubits, and having a C-NOT error of less than or equal to 10^{-3};

   3. Quantum computers supporting 200 or more, but fewer than 350, fully controlled, connected and working physical qubits, and having a C-NOT error of less than or equal to $2x10^{-3}$;

   4. Quantum computers supporting 350 or more, but fewer than 500, fully controlled, connected and working physical qubits, and having a C-NOT error of less than or equal to $3x10^{-3}$;

   5. Quantum computers supporting 500 or more, but fewer than 700, fully controlled, connected and working physical qubits, and having a C-NOT error of less than or equal to $4x10^{-3}$;

   6. Quantum computers supporting 700 or more, but fewer than 1 100, fully controlled, connected and working physical qubits, and having a C-NOT error of less than or equal to $5x10^{-3}$;

   7. Quantum computers supporting 1 100 or more, but fewer than 2 000, fully controlled, connected and working physical qubits, and having a C-NOT error of less than or equal to $6x10^{-3}$;

   8. Quantum computers supporting 2 000 or more fully controlled, connected and working physical qubits;

b. Qubit devices and qubit circuits containing or supporting arrays of physical qubits, and specially designed for items specified by 4A1901;

c. Quantum control components and quantum measurement devices, specially designed for items specified by 4A1901;

Notes:

1. 4A1901 applies to circuit model (or 'gate-based') and one-way (or 'measurement-based' - MBQC) quantum computers.

([48]) Equivalent national code: 4.A.901.
([49]) Annex III.5 of the Royal Decree 679/2014 of 1 August 2014, with entry into force on 7 June 2023.

2. *Items specified in 4A1901 need not necessarily physically contain any qubits. For example, quantum computers based on photonic schemes do not permanently contain a physical item that can be identified as a qubit. The photonic qubits are generated while the computer is operating and are then later discarded.*

3. *Items specified in 4A1901 include semiconductors, superconductors, and photonic qubit chips and chip arrays; ion trap arrays; other qubit confinement technologies; and coherent interconnects between those elements.*

4. *4A1901 applies to items designed for calibrating, initialising, manipulating or measuring the resident qubits of a quantum computer.*

Technical notes:

For the purposes of 4A1901:

1. *A physical qubit is a two-level quantum system used to represent the elementary unit of quantum logic by means of manipulations and measurements that are not error corrected. Physical qubits differ from logical qubits in that the latter are error-corrected qubits made up of many physical qubits.*

2. *Fully controlled means the physical qubit can be calibrated, initialised, gated and read out, as necessary.*

3. *Connected means that two-qubit gate operations can be performed between any arbitrary pair of the available working physical qubits. This does not necessarily entail 'all-to-all' connectivity.*

4. *Working means that the physical qubit performs universal quantum computational work functions according to system specifications for volume and capacity measurements, in accordance with qubit operational fidelity.*

5. *Supporting 34 or more fully controlled, connected, working physical qubits refers to the capability of a quantum computer to confine, control, measure and process the quantum information embodied in 34 or more physical qubits.*

6. *C-NOT error is the average physical gate error for the Controlled-NOT (C-NOT) nearest-neighbour gates of two physical qubits.*

4A1906 ([50])

Issued by France ([51])

Additional information:

Description of the controlled items:

Quantum computers and related 'electronic assemblies' and components therefor, as follows:

a. Quantum computers, as follows:

   1. Quantum computers supporting 34 or more, but fewer than 100, 'fully controlled', 'connected' and 'working' 'physical qubits', and having a 'C-NOT error' of less than or equal to 10^{-4} ;

   2. Quantum computers supporting 100 or more, but fewer than 200, 'fully controlled', 'connected' and 'working' 'physical qubits', and having a 'C-NOT error' of less than or equal to 10^{-3} ;

   3. Quantum computers supporting 200 or more, but fewer than 350, 'fully controlled', 'connected' and 'working' 'physical qubits', and having a 'C-NOT error' of less than or equal to $2x10^{-3}$;

   4. Quantum computers supporting 350 or more, but fewer than 500, 'fully controlled', 'connected' and 'working' 'physical qubits', and having a 'C-NOT error' of less than or equal to $3x10^{-3}$;

([50]) Equivalent national code: 4A906.

([51]) Order of 2 February 2024 on exports to third countries of goods and technologies associated with quantum computers and their enabling technologies, and of equipment to design, develop, produce, test and inspect advanced electronic components.

5. Quantum computers supporting 500 or more, but fewer than 700, 'fully controlled', 'connected' and 'working' 'physical qubits', and having a 'C-NOT error' of less than or equal to $4x10^{-3}$;

6. Quantum computers supporting 700 or more, but fewer than 1 100, 'fully controlled', 'connected' and 'working' 'physical qubits', and having a 'C-NOT error' of less than or equal to $5x10^{-3}$;

7. Quantum computers supporting 1 100 or more, but fewer than 2 000, 'fully controlled', 'connected' and 'working' 'physical qubits', and having a 'C-NOT error' of less than or equal to $6x10^{-3}$;

8. Quantum computers supporting 2 000 or more 'fully controlled', 'connected' and 'working' 'physical qubits' ;

b. Qubit devices and qubit circuits, containing or supporting arrays of 'physical qubits', and specially designed for items specified by 4A1906.a ;

c. Quantum control components and quantum measurement devices, specially designed for items specified by 4A1906.a;

Notes:

1. *4A1906 applies to circuit model (or gate-based) and one-way (or measurement-based) quantum computers. This entry does not apply to adiabatic (or annealing) quantum computers.*

2. *Items specified by 4A1906 may not necessarily physically contain any qubits. For example, quantum computers based on photonic schemes do not permanently contain a physical item that can be identified as a qubit. The photonic qubits are generated while the computer is operating and are then later discarded.*

3. *Items specified in 4A1906.b include semiconductor, superconducting, and photonic qubit chips and chip arrays; surface ion trap arrays; other qubit confinement technologies; and coherent interconnects between such items.*

4. *4A1906.c applies to items designed for calibrating, initialising, manipulating or measuring the resident qubits of a quantum computer.*

Technical Notes:

1. *A 'physical qubit' is a two-level quantum system used to represent the elementary unit of quantum logic by means of manipulations and measurements that are not error corrected. 'Physical qubits' are distinguished from logical qubits, in that logical qubits are error-corrected qubits comprised of many 'physical qubits'.*

2. *'Fully controlled' means the 'physical qubit' can be calibrated, initialised, gated, and read out, as necessary.*

3. *'Connected' means that two-qubit gate operations can be performed between any arbitrary pair of the available 'working' 'physical qubits'. This does not necessarily entail all-to-all connectivity.*

4. *'Working' means that the 'physical qubit' performs universal quantum computational work according to the system specifications for qubit operational fidelity.*

5. *Supporting 34 or more 'fully controlled', 'connected', 'working' 'physical qubits' refers to the capability of a quantum computer to confine, control, measure and process the quantum information embodied in 34 or more 'physical qubits'.*

6. *'C-NOT error' is the average physical gate error for the nearest-neighbour two-'physical qubit' Controlled-NOT (C-NOT) gates.*

4D Software

4D1901.b.3 ([52])

Issued by France ([53])

Additional information:

Description of the controlled items:

'Software' specially designed or modified for the 'development' or 'production' of items specified in 4A1906.b or 4A1906.c.

4E Technology

4E1901 ([54])

Issued by Spain ([55])

Additional information:

Description of the controlled items:

Technology for the development or production of quantum computers, devices and qubit circuits, as well as quantum measurement and control components specified in 4A1901.

4E1902.b.3 ([56])

Issued by France ([57])

Additional information:

Description of the controlled items:

'Technology' within the meaning of the General Technology Note in Annex I to the Regulation for the 'development' or 'production' of items specified in 4A1906.b or 4A1906.c.

([52]) Equivalent national code: 4D901.b.3.
([53]) Order of 2 February 2024 on exports to third countries of goods and technologies associated with quantum computers and their enabling technologies, and of equipment to design, develop, produce, test and inspect advanced electronic components.
([54]) Equivalent national code: 4.E.901.
([55]) Annex III.5 of the Royal Decree 679/2014 of 1 August 2014, with entry into force on 7 June 2023.
([56]) Equivalent national code: 4E901.b.3.
([57]) Order of 2 February 2024 on exports to third countries of goods and technologies associated with quantum computers and their enabling technologies, and of equipment to design, develop, produce, test and inspect advanced electronic components.